

WHAT IS CLAIMED IS:

1. A shaft sealing apparatus, comprising:
 - a vacuum casing formed with a vacuum chamber;
 - 5 a driving shaft having an outer cylindrical surface and movably extending in said vacuum chamber of said vacuum casing; and
 - a sealing ring in the form of an annular ring shape and including a sealing lip held in contact with said outer cylindrical surface of said driving shaft, an annular spring member operative to impart a force to said sealing lip to ensure that said
 - 10 sealing lip is held in tight contact with said outer cylindrical surface of said driving shaft, and a peripheral portion radially outwardly extending from said sealing lip, in which said outer cylindrical surface of said driving shaft is smaller in surface roughness Ra than 0.1 (μ m).
- 15 2. A shaft sealing apparatus as set forth in claim 1, in which said outer cylindrical surface of said driving shaft is larger in Vickers hardness Hv than 650.
3. A shaft sealing apparatus as set forth in claim 1, in which said annular spring member of said sealing ring is made of a metal wire in the form of a helical shape and
- 20 is of a circular cross-section taken on the plane perpendicular to the center axis passing therethrough.
4. A shaft sealing apparatus as set forth in claim 1, in which said annular spring member of said sealing ring is made of a metal plate in the form of a annular ring
- 25 shape and is of a channel-shaped cross-section taken on the plane perpendicular to the center axis passing therethrough.
5. A shaft sealing apparatus as set forth in claim 1, in which said sealing lip of said sealing ring is made of a synthetic resin constituted by an ultra high molecular
- 30 weight compound.
6. A shaft sealing apparatus, comprising:
 - a vacuum casing formed with a vacuum chamber and having a base portion formed with an opening to have said vacuum chamber of said vacuum casing held in
 - 35 communication with the atmosphere through said opening of said vacuum casing;
 - a shaft housing in the form of a cylindrical hollow shape and fixedly connected with said base portion of said vacuum casing, said shaft housing having an

inner cylindrical surface;

a driving shaft in the form of a cylindrical shape and received in said shaft housing to be movably supported by said shaft housing, said driving shaft held in coaxial alignment with said shaft housing and having a first axial end extending in
 5 said vacuum chamber of said vacuum casing, a second axial end extending in the atmosphere, and an outer cylindrical surface smaller in diameter than said inner cylindrical surface of said shaft housing; and

a sealing unit received in said opening of said vacuum casing and fixedly supported by said base portion of said vacuum casing, said sealing unit including a
 10 retaining member in the form of an annular ring shape and fixedly connected with said base portion of said vacuum casing, and a sealing ring in the form of an annular ring shape and securely retained by said retaining member of said sealing unit, said sealing ring of said sealing unit intervening between said driving shaft and said retaining member of said sealing unit to hermetically seal the gap between said
 15 driving shaft and said retaining member of said sealing unit, said sealing ring of said sealing unit including an annular resilient member formed with an annular groove, and an annular spring member received in said annular groove of said annular resilient member and retained by said annular resilient member, said annular resilient member of said sealing ring having a peripheral portion securely retained by said
 20 retaining member, and a sealing lip integrally formed with said peripheral portion of said annular resilient member and radially inwardly extending from said peripheral portion of said annular resilient member to be held in contact with said outer cylindrical surface of said driving shaft, said annular spring member of said sealing ring operative to impart a force to said sealing lip of said annular resilient member to
 25 ensure that said sealing lip of said annular resilient member is held in tight contact with said outer cylindrical surface of said driving shaft.

7. A shaft sealing apparatus as set forth in claim 6, in which said driving shaft is rotatable around its own axis with respect to said shaft housing.

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8. A shaft sealing apparatus as set forth in claim 6, in which said driving shaft is axially movable along its own axis with respect to said shaft housing.

9. A shaft sealing apparatus, comprising:

35 a vacuum casing formed with a vacuum chamber and having a base portion formed with an opening to have said vacuum chamber of said vacuum casing held in communication with the atmosphere through said opening of said vacuum casing;

a shaft housing in the form of a cylindrical hollow shape and fixedly connected with said base portion of said vacuum casing, said shaft housing having an inner cylindrical surface;

5 a sleeve shaft in the form of a cylindrical hollow shape and received in said shaft housing to be movably supported by said shaft housing, said sleeve shaft held in coaxial alignment with said shaft housing and having a first axial end extending in said vacuum chamber of said vacuum casing, a second axial end extending in the atmosphere, an outer cylindrical surface smaller in diameter than said inner cylindrical surface of said shaft housing, and an inner cylindrical surface;

10 a center shaft in the form of a cylindrical shape and received in said sleeve shaft to be movably supported by said sleeve shaft, said center shaft held in coaxial alignment with said sleeve shaft and having a first axial end extending in said vacuum chamber of said vacuum casing, a second axial end extending in the atmosphere, and an outer cylindrical surface smaller in diameter than said inner cylindrical surface of said sleeve shaft;

15 a first sealing unit provided on said first axial end of said sleeve shaft and held in coaxial alignment with said sleeve shaft, said first sealing unit including a retaining member in the form of an annular ring shape and fixedly connected with said first axial end of said sleeve shaft, and a sealing ring in the form of an annular ring shape and securely retained by said retaining member of said first sealing unit, said sealing ring of said first sealing unit intervening between said center shaft and said retaining member of said first sealing unit to hermetically seal the gap between said center shaft and said retaining member of said first sealing unit, said sealing ring of said first sealing unit including an annular resilient member formed with an annular groove, and an annular spring member received in said annular groove of said annular resilient member and retained by said annular resilient member, said annular resilient member of said sealing ring having a peripheral portion securely retained by said retaining member, and a sealing lip integrally formed with said peripheral portion of said annular resilient member and radially inwardly extending from said peripheral portion of said annular resilient member to be held in contact with said outer cylindrical surface of said center shaft, said annular spring member of said sealing ring operative to impart a force to said sealing lip of said annular resilient member to ensure that said sealing lip of said annular resilient member is held in tight contact with said outer cylindrical surface of said center shaft; and

30 a second sealing unit received in said opening of said vacuum casing and fixedly supported by said base portion of said vacuum casing, said second sealing unit including a retaining member in the form of an annular ring shape and fixedly

- connected with said base portion of said vacuum casing, and a sealing ring in the form of an annular ring shape and securely retained by said retaining member of said second sealing unit, said sealing ring of said second sealing unit intervening between said retaining member of said first sealing unit and said retaining member of said
- 5 second sealing unit to hermetically seal the gap between said retaining member of said first sealing unit and said retaining member of said second sealing unit, said sealing ring of said second sealing unit including an annular resilient member formed with an annular groove, and an annular spring member received in said annular groove of said annular resilient member and retained by said annular resilient member,
- 10 said annular resilient member of said sealing ring having a peripheral portion securely retained by said retaining member, and a sealing lip integrally formed with said peripheral portion of said annular resilient member and radially inwardly extending from said peripheral portion of said annular resilient member to be held in contact with said outer cylindrical surface of said first sealing unit, said annular spring
- 15 member of said sealing ring operative to impart a force to said sealing lip of said annular resilient member to ensure that said sealing lip of said annular resilient member is held in tight contact with said outer cylindrical surface of said first sealing unit.
- 20 10. A shaft sealing apparatus as set forth in claim 9, in which said sleeve shaft is rotatable around its own axis with respect to said shaft housing.
11. A shaft sealing apparatus as set forth in claim 9, in which said sleeve shaft is axially movable along its own axis with respect to said shaft housing.
- 25 12. A shaft sealing apparatus as set forth in claim 9, in which said center shaft is rotatable around its own axis with respect to said sleeve shaft.
13. A shaft sealing apparatus as set forth in claim 9, in which said center shaft is
- 30 axially movable along its own axis with respect to said sleeve shaft.
14. A shaft sealing apparatus, comprising:
- a vacuum casing formed with a vacuum chamber and having a base portion formed with an opening to have said vacuum chamber of said vacuum casing held in
- 35 communication with the atmosphere through said opening of said vacuum casing;
- a shaft housing in the form of a cylindrical hollow shape and fixedly connected with said base portion of said vacuum casing, said shaft housing having an

inner cylindrical surface;

5 a sleeve shaft in the form of a cylindrical hollow shape and received in said shaft housing to be movably supported by said shaft housing, said sleeve shaft held in coaxial alignment with said shaft housing and having a first axial end extending in said vacuum chamber of said vacuum casing, a second axial end extending in the atmosphere, an outer cylindrical surface smaller in diameter than said inner cylindrical surface of said shaft housing, and an inner cylindrical surface;

10 a center shaft in the form of a cylindrical shape and received in said sleeve shaft to be movably supported by said sleeve shaft, said center shaft held in coaxial alignment with said sleeve shaft and having a first axial end extending in said vacuum chamber of said vacuum casing, a second axial end extending in the atmosphere, and an outer cylindrical surface smaller in diameter than said inner cylindrical surface of said sleeve shaft;

15 a first sealing unit fixedly supported by said sleeve shaft, said first sealing unit including a retaining member in the form of an annular ring shape and fixedly supported by said sleeve shaft, and a sealing ring in the form of an annular ring shape and securely retained by said retaining member of said first sealing unit, said sealing ring of said first sealing unit intervening between said center shaft and said retaining member of said first sealing unit to hermetically seal the gap between said center shaft and said retaining member of said first sealing unit, said sealing ring of said first sealing unit including an annular resilient member formed with an annular groove, and an annular spring member received in said annular groove of said annular resilient member and retained by said annular resilient member, said annular resilient member of said sealing ring having a peripheral portion securely retained by said retaining member, and a sealing lip integrally formed with said peripheral portion of said annular resilient member and radially inwardly extending from said peripheral portion of said annular resilient member to be held in contact with said outer cylindrical surface of said center shaft, said annular spring member of said sealing ring operative to impart a force to said sealing lip of said annular resilient member to ensure that said sealing lip of said annular resilient member is held in tight contact with said outer cylindrical surface of said center shaft; and

30 a second sealing unit fixedly supported by said base portion of said vacuum casing, said second sealing unit including a retaining member in the form of an annular ring shape and fixedly supported by said base portion of said vacuum casing, and a sealing ring in the form of an annular ring shape and securely retained by said retaining member of said second sealing unit, said sealing ring of said second sealing unit intervening between said sleeve shaft and said retaining member of said second

sealing unit to hermetically seal the gap between said sleeve shaft and said retaining member of said second sealing unit, said sealing ring of said second sealing unit including an annular resilient member formed with an annular groove, and an annular spring member received in said annular groove of said annular resilient member and retained by said annular resilient member, said annular resilient member of said sealing ring having a peripheral portion securely retained by said retaining member, and a sealing lip integrally formed with said peripheral portion of said annular resilient member and radially inwardly extending from said peripheral portion of said annular resilient member to be held in contact with said outer cylindrical surface of said sleeve shaft, said annular spring member of said sealing ring operative to impart a force to said sealing lip of said annular resilient member to ensure that said sealing lip of said annular resilient member is held in tight contact with said outer cylindrical surface of said sleeve shaft.

15. A shaft sealing apparatus as set forth in claim 14, which further comprises a first labyrinth seal unit intervening between said sleeve shaft and said center shaft to be exposed to said vacuum chamber of said vacuum casing, and a second labyrinth seal unit intervening between said vacuum casing and said sleeve shaft to be exposed to said vacuum chamber of said vacuum casing, said first labyrinth seal unit including an outer ring member provided on said first axial end of said sleeve shaft, and an inner ring member provided on said first axial end of said center shaft, said outer and inner ring members of said first labyrinth seal unit collectively forming an interstice therebetween, said second labyrinth seal unit including an outer ring member provided on said base portion of said vacuum casing, and an inner ring member provided on said first axial end of said sleeve shaft, said outer and inner ring members of said second labyrinth seal unit collectively forming an interstice therebetween.

16 A shaft sealing apparatus as set forth in claim 15, which further comprises a base member in the form of a circular shape and provided on said first axial end of said center shaft, a first fixed member in the form of an annular ring shape and provided on said first axial end of said sleeve shaft, and a second fixed member in the form of an annular ring shape and provided on said base portion of said vacuum casing, said base member and said first fixed member collectively constituting said first labyrinth seal unit, said first and second fixed members collectively constituting said second labyrinth seal unit.

17. A shaft sealing apparatus as set forth in claim 14, in which said sleeve shaft

is rotatable around its own axis with respect to said shaft housing.

18. A shaft sealing apparatus as set forth in claim 14, in which said sleeve shaft is axially movable along its own axis with respect to said shaft housing.

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19. A shaft sealing apparatus as set forth in claim 14, in which said center shaft is rotatable around its own axis with respect to said sleeve shaft.

20. A shaft sealing apparatus as set forth in claim 14, in which said center shaft
10 is axially movable along its own axis with respect to said sleeve shaft.